REMARKS

The Examiner is thanked for the interview courteously granted to the undersigned, in connection with the above-identified application. During this interview, clarification was obtained by the undersigned in connection with the prior art rejection of claim 1. In particular, it was clarified that in essence the rejection was over the disclosure of the article by Hayashi, et al., in International Electron Devices Meeting Technical Digest, 1992, at page 976, as described in column 2, lines 44-59 of U.S. Patent No. 5,607,718 to Sasaki, et al. It was noted that this article of Hayashi, et al. had been made of record in the parent application of the above-identified application, that is, Application No. 09/763,891, filed February 28, 2001. Differences between the teachings of the article by Hayashi, et al. and the present invention were discussed, and advantages achieved by the present invention due to these differences were also discussed. No agreement was reached during the interview.

Applicants have amended their specification on page 13, to correct a typographical error therein. In view thereof, the required correction set forth in Item 2 on page 2 of the Office Action mailed February 7, 2003, has been made.

Applicants have amended their claims in order to further clarify the definition of various aspects of the present invention. Specifically, claims 1 and 2 have been cancelled without prejudice or disclaimer, and new claims 3-17 added to the application. Of these newly added claims, which are all directed to a polishing solution for polishing a metal film surface, claims 3, 10 and 14 are independent claims.

Claim 3 recites that the solution includes an additive which is capable of etching the metal film surface at an etching rate of at most 10nm/minute; a protective film-forming agent which, in combination with the additive, is capable of removing the metal film surface by chemical mechanical polishing at a polishing rate of at least 100nm/minute and an etching rate of not more than 10nm/minute; and water. Claim 4, dependent on claim 3, recites that the additive is a combination of a first material which is an oxidizer of metal of the metal film surface, thereby forming an oxide of the metal, a second material which dissolves this oxide of the metal, and another protective film-forming agent different from the protective film-forming agent recited in claim 3. Claims 5 and 6, dependent respectively on claims 4 and 3, recite that the solution consists essentially the additive, the protective film-forming agent and water. Claims 7 and 8, dependent on claim 3, each further define the protective film-forming agent; and claim 9, also dependent on claim 3, recites that the solution is adapted to polish a metal film surface that includes a material that contains at least one of copper, a copper alloy, a copper oxide and a copper alloy oxide.

Independent claim 10 recites that the polishing solution includes an additive which is capable of removing metal of the metal film surface by chemical mechanical polishing; a first protective film-forming agent; a second protective film-forming agent; and water. Claim 11, dependent on claim 10, further defines the additive, as a combination of another protective film-forming agent and a material that oxidizes metal of the metal film surface; and claim 12, dependent on claim 10, recites that the solution is capable of removing the metal film surface by chemical mechanical polishing at a polishing rate of at least 100nm/minute and an etching rate of at most

10nm/minute. Claim 13, dependent on claim 10, recites that the solution consists essentially of the additive, the first protective film-forming agent, the second protective film-forming agent and water.

Independent claim 14 recites that the polishing solution includes an oxidized metal dissolving agent, which dissolves an oxide of metal of the metal film surface; an additive which is capable of forming a protective film by at least one of physical adsorption and chemical linkage on the metal film surface; a protective film-forming agent; and water. Claim 15 recites the same subject matter as expressly set forth in claim 12, but is dependent on claim 14; and claim 16, dependent on claim 14, recites that the additive includes an oxidizing agent that oxidizes the metal of the metal film surface. Claim 17, dependent on claim 14, recites that the solution consists essentially of the oxidized metal dissolving agent, the additive, the protective film-forming agent and water.

The failure by the Examiner to consider the Information Disclosure Statement filed October 15, 2001, in the above-identified application, the Examiner contending that provisions of 37 CFR § 1.97, 1.98 and MPEP §609 were not complied with, in that copies of the references or English equivalents thereof were not provided, is noted. It must be emphasized, however, that the references and respective translation/abstract were provided in a prior application of the above-identified application, Application No. 09/763,891, filed February 28, 2001, which is being relied upon under 35 USC § 120 in the above-identified application. Accordingly, copies of the listed documents need not be provided in the present application. See 37 CFR § 1.98(d).

The contention by the Examiner concerning references "US 5,770,095, WO 98/04646, and JP-A-5-228528" in Item 1 on page 2 of the Office Action mailed February 7, 2003, is noted. To clarify the record, the "THIRD-PARTY SUBMISSION IN PUBLISHED APPLICATION UNDER 37 C.F.R. § 1.99" submitted in connection with the above-identified application, which submitted the three (3) above-listed references, is noted. Insofar as this third-party submission satisfies requirements of 37 CFR § 1.99, it is respectfully submitted that the Examiner must consider the submitted documents. In this regard, it is noted that the Examiner has cited one of the documents referred to in the third-party submission, in the Form PTO-892 enclosed with the Office Action mailed February 7, 2003 (that is, U.S. Patent No. 5,770,095 to Sasaki, et al.).

The rejection of claim 2 under the second paragraph of 35 USC §112, set forth in Item 4 on page 3 of the Office Action mailed February 7, 2003, is noted. In view of canceling of claim 2, and adding of the new claims, which new claims do not include the expression "a metal etching rate inhibitor", it is respectfully submitted that the indefiniteness rejection is moot.

Applicants respectfully submit that all of the claims now presented for consideration by the Examiner patentably distinguish over the teachings of the references as applied by the Examiner in rejecting claims in the Office Action mailed February 7, 2003, that is, the teachings of the U.S. patents to Sasaki, et al., No. 5,607,718 (Sasaki '718), and to Sasaki, et al., No. 5,770,095 (Sasaki '095), under the provisions of 35 USC §102 and 35 USC §103. Moreover, as clarified during the above-mentioned interview, and as discussed infra, it is respectfully

submitted that the teachings of the article by Hayashi, et al., "A New Abrasive-Free, Chemical-Mechanical-Polishing Technique For Aluminum Metalization of ULSI Devices", in IEDM 92, pages 976-8, would have neither taught nor would have suggested the presently claimed invention.

It is respectfully submitted that the teachings of the references as applied by the Examiner would have neither disclosed nor would have suggested such a polishing solution as in the present claims, including, inter alia, an additive which is capable of etching the metal film surface at an etching rate of at most 10nm/minute, and a protective film-forming agent which, in combination with the additive, is capable of removing the metal film surface by chemical mechanical polishing at a polishing rate of at least 100nm/minute and an etching rate of not more than 10nm/minute. See claim 3.

More specifically, it is respectfully submitted that these references would have neither taught nor would have suggested such a polishing solution as referred to in previous paragraphs, and wherein the additive is a combination of a first material which is an oxidizer of metal of the metal film surface, a second material which dissolves the oxide of this metal, and another protective film-forming agent different from the protective film-forming agent defined in claim 3. See claim 4.

Furthermore, it is respectfully submitted that the teachings of the applied references would have neither disclosed nor would have suggested such polishing solution as in the present claims, having, inter alia, the additive which is capable of removing metal of the metal film surface by chemical mechanical polishing, and first and second protective film-forming agents. See claim 10.

More specifically, it is respectfully submitted that the teachings of the applied prior art would have neither disclosed nor would have suggested such a polishing solution as in the present claims, having the components as referred to above in connection with claim 10, and in particular wherein the additive is a combination of another protective film-forming agent and a material that oxidizes metal of the metal film surface. See claim 11.

Moreover, it is respectfully submitted that the teachings of the applied references would have neither disclosed nor would have suggested such a polishing solution as in the present claims, including, inter alia, an oxidized metal dissolving agent which dissolves an oxide of metal of the metal film surface, an additive which is capable of forming a protective film by at least one of physical adsorption and chemical linkage on the metal film surface, and a protective film-forming agent. See claim 14.

More specifically, it is respectfully submitted that the teachings of the applied references would have neither disclosed nor would have suggested such a polishing solution as referred to previously in connection with claim 14, and in particular wherein the additive includes an oxidizing agent that oxidizes the metal of the metal film surface. See claim 16.

In addition, it is respectfully submitted that the teachings of the applied references would have neither disclosed nor would have suggested such a polishing solution as in the present claims, including wherein the solution is capable of removing the metal film surface by chemical mechanical polishing at a polishing rate of at least 100nm/minute and at an etching rate of at most 10nm/minute. Note

claim 3; see also claims 12 and 15.

Furthermore, it is respectfully submitted that the teachings of the applied references do not disclose, nor would have suggested, such a polishing solution, consisting essentially of the component as set forth in the various claims. See claims 5, 6, 13 and 17.

Furthermore, it is respectfully submitted that the teachings of the applied prior art would not have disclosed nor would have suggested such solution as in the present claims, including the specific components thereof as in claims 7 and 8; and, moreover, wherein the polishing solution as in claim 3 is adapted to polish a metal film surface that includes a material that contains at least one of copper, a copper alloy, a copper oxide and a copper alloy oxide (see claim 9).

The invention as claimed in the above-identified application is directed to a polishing solution for polishing a metal, particularly suitable for polishing in forming wirings of semiconductor devices.

In recent years, chemical-mechanical polishing has been performed in manufacturing semiconductor integrated circuits, particularly in the planarizing of interlayer insulating films, and in the formation of metal plugs and formation of buried wirings, for example, in the step of forming multi-layer wiring. In a common method for chemical-mechanical polishing, a polishing pad is stuck onto a circular polishing surface plate, the surface of the polishing pad is soaked with a polishing slurry for metal, the surface of the substrate on which a metal film has been formed is pressed against the pad surface, and a polishing platen is rotated in a state in which a preset pressure is applied, so that hills of the metal film are removed by mechanical friction

between the polishing slurry (which contains abrasives) and the hills of the metal film. The abrasive in the slurry is a solid abrasive particle or powder.

However, when a conventional polishing slurry containing solid abrasive grains is used, there are problems in which the middle portion of the surface of a buried metal wiring is isotropically corroded to become hollow like a dish (dishing); polishing scratches due to the solid abrasive grains may occur, a complicated cleaning process is required for removing any solid abrasive grains remaining on the substrate surface after polishing; and the initial cost of the solid abrasive grains themselves and the disposal of waste liquid brings about a high cost. Note the paragraph bridging pages 4 and 5 of Applicants' specification.

In order to avoid the problem of dishing, which is, e.g., due to excessive etching of the metal surface being polished, a method making use of a polishing solution which contains an oxidized-metal dissolving agent comprised of aminoacetic acid or amidosulfuric acid and benzotriazole has been proposed. However, the benzotriazole has so high a protective film-forming effect that it may cause a great decrease not only in etching rate of the metal, but also a polishing rate thereof.

Accordingly, it is still desired to provide a polishing solution which avoids the need for solid abrasive particles and whichavoids problems of, e.g., dishing and erosion (e.g., silicon oxide loss from the surface being polished).

Applicants have found that the foregoing problems are avoided through a polishing solution as in the present invention, having, inter alia, the recited additive, protective film-forming agents and water. In particular, in an illustrative specific embodiment, and not to be limiting, the polishing solution according to the present

invention includes an oxidizer for the metal, a solubilizing agent which dissolves this oxide, and first and second protective film-forming agents, in addition to the water. In general, the polishing solution according to the present invention includes various additives and components as recited in the present claims, achieving functions as defined therein.

Applicants provide a polishing solution which overcomes the foregoing problems. Applicants have found that the foregoing problems are overcome by a polishing solution which achieves a polishing rate of at least 100nm/minute, while such solution has an etching rate of not more than 10nm/minute. As to what is meant by "etch rate" according to the present invention, note, for example, the paragraph bridging pages 10 and 11 of Applicants' specification. That is, the present invention provides a relatively high rate of polishing, so as to achieve the desired smoothing, while avoiding substantial etching of the polished metal, thereby avoiding problems of dishing, erosion, etc. which can occur using solutions having undesirably high rates of etching. Moreover, by utilizing a polishing solution as in the present invention, wherein abrasive particulate can be avoided, scratching problems can be avoided.

Thus, according to the present invention, the solution contains, illustratively, an etchant to make the metal oxide film, e.g., formed from metal of the metal film surface being polished, water-soluble, and a corrosion inhibitor to suppress polishing in recessed areas. Only the protruding regions are selectively polished; the selectivity is an important aspect of the abrasives-free technology according to the present invention.

While the Examiner has applied Sasaki '718, this reference has been applied only insofar as it discusses the Hayashi, et al. article. That is, Sasaki '718 discloses that the Hayashi, et al. article teaches a method using no polishing particles, in which aluminum plugs are formed by polishing using a solution mixture of an amine and hydrogen peroxide water. Sasaki '718 discloses that, in the procedure described in the article, since no polishing particles are used, the polishing proceeds merely chemically, and neither flaws nor roughness rarely take place in aluminum; however, dishing occurs significantly because the ratio (polishing velocity/dissolution velocity) of the polishing velocity of aluminum to the dissolution velocity of aluminum with respect to the solution mixture is low.

More particularly, the article of Hayashi, et al. discloses a polishing technique for aluminum metalization, in which aqueous amine and hydrogen peroxide solution is used as a polishing liquid, and scratch-free aluminum plugs embedded in SiO_2 are obtained by this polishing with a high polishing selectivity of the aluminum to SiO_2. This article discloses that to minimize the chemical etching inside the aluminum plug or so-called as over-etching, a high polishing pressure condition such as greater than 0.4kg/cm_2 was selected.

It is emphasized that Hayashi, et al. discloses a polishing solution containing an amine and aqueous hydrogen peroxide. It is respectfully submitted that Hayashi, et al. would have neither taught nor would have suggested such a polishing solution as in the present claims, including the additive, and protective film-forming agent which, in combination with the additive, is capable of removing the metal surface by chemical mechanical polishing at a polishing rate of at least 100nm/minute and an

etching rate of not more than 10nm/minute, and water (see claim 3); and/or the polishing solution which contains the additive which is capable of removing metal of the metal film surface by chemical mechanical polishing, together with the first and second protective film-forming agents, with water (see claim 10); and/or the polishing solution which includes the oxidized metal dissolving agent which dissolves an oxide of metal of the metal film surface, the additive capable of forming a protective film by at least one of physical adsorption and chemical linkage on the metal film surface, and the protective film-forming agent, with water (see claim 14); or the other aspects of the present invention as discussed previously, and advantages thereof.

Sasaki '095 discloses a polishing agent and polishing method, for use in a micro-processing step. The polishing agent includes a chemical agent responsible for forming a protection film on the surface of the substrate to be polished by reacting with the material containing a metal as a main component. See column 2, lines 7-15. Sasaki '095 discloses that it is preferred that the polishing agent contain an aminoacetic acid and/or an amidosulfuric acid, an oxidizing agent, water and benzotriazole. Sasaki '095 reports on the investigation of change in polishing rate and etching rate relative to the addition amount of benzotriazole, the results being shown in Fig. 4. As described in this patent, where benzotriazole is not added, a polishing rate as high as approximately 350nm/minute and an etching rate as high as approximately 45nm/minute occurs; and as the amount of benzotriazole increases, both polishing rate and etching rate decrease exponentially.

Noting particularly the disclosure in Sasaki '095 concerning exponential decrease in both polishing and etching rates in adding benzotriazole, it is respectfully submitted that this reference does not disclose, nor would have suggested, a polishing solution as in the present claims, including components wherein a polishing rate of at least 100nm/minute and an etching rate of not more than 10nm/minute, are achieved. Moreover, this reference does not disclose, nor would have suggested, a polishing solution, including the protective film-forming agents and other components, achieving the relatively high polishing rate while having a relatively low etching rate, as achieved by the present invention.

It is emphasized that advantages achieved according to the present invention, including the functions achieved by the claimed solution, are obtained due to the combination of components. In this regard, attention is respectfully directed to pages 27 and 28 of Applicants' specification. That is, as described in the paragraph bridging pages 27 and 28, the first protective film-forming agent (e.g., benzotriazole) has the action of forming a strong protective film on the metal surface. The film thus formed is so tough that, when a polishing solution for metal is used which contains, e.g., 0.5% by weight of benzotriazole, the film is usually little polished only a little, even where solid abrasive grains are contained in the polishing solution. On the other hand, where the polishing solution for metal is prepared not using the first protective film-forming agent and using only the second protective film-forming agent alone, it is difficult especially to control the etching rate, ensuring no sufficient protective effect.

In contrast, through use of the first and second protective film-forming agents in combination, which permits use of relatively small amount of the first film-forming agent providing a tough film, both control of etching rate and maintaining increased polishing rate can be achieved, making it unnecessary to rely on use of solid abrasive grains.

Moreover, a solution having a high polishing rate (at least 100 nm/minute) and a low etching rate (not more than 10 nm/minute) is achieved, having the advantage that, e.g., dishing is avoided. The teachings of the applied references do not disclose, nor would have suggested, avoiding problems in, e.g., dishing, when using a polishing solution having a polishing rate and etching rate as in the present claims, while sufficiently speedily performing the polishing.

It is respectfully submitted that the teachings of the applied references do not disclose, nor would have suggested, the solution according to the present invention, including combination of components thereof, for example, use of the combination of first and second protective film-forming agents, and advantages achieved thereby including high polishing rate and low etching rate.

Reference by the Examiner to use of benzotriazole in Sasaki '095, in Item 7 bridging pages 4 and 5 of the Office Action mailed February 7, 2003, is noted. It must be emphasized that benzotriazole, when included in a polishing solution as the sole protective film-forming agent, reduces the polishing rate such that the polishing rate is unsatisfactorily reduced. That is, if the etching rate is reduced such that, for example, dishing can be avoided, using a polishing solution containing only

benzotriazole as a protective film-forming agent, this polishing solution is unsatisfactory due to disadvantageously reduced polishing rate.

As is clear from the foregoing, as well as from a full review of Applicants' disclosure, problems arising in connection with utilizing only benzotriazole as a film-forming agent can be avoided according to the present invention, utilizing, for example, the disclosed components such as, for example, first and second protective film-forming agents. It is respectfully submitted that Sasaki '095 does not disclose, nor would have suggested, such solution as in the present claims, including, inter alia, the protective film-forming agents and other components, or the recited additive, which, as part of the polishing solution, achieves the polishing rate of at least 100nm/minute and etching rate of not more than 10nm/minute, as discussed previously, wherein, e.g., dishing can be avoided.

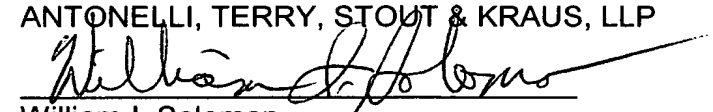
In view of the foregoing comments and amendments, reconsideration and allowance of all claims presently in the application are respectfully requested.

Attached hereto is a marked-up version of the changes made to the specification by the current Amendment. The changes are shown in the Attachment captioned "VERSION WITH MARKINGS TO SHOW CHANGES MADE".

To the extent necessary, Applicants petition for an extension of time under 37 CFR 1.136, please charge any shortage in fees due in connection with the filing of this paper to the Deposit Account No. 01-2135 (Case No. 566.39787CX1) and please credit any excess fees to such Deposit Account.

Respectfully submitted,

ANTONELLI, TERRY, STOUT & KRAUS, LLP



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"VERSION WITH MARKINGS TO SHOW CHANGES MADE"

The metal-oxidizing agent may include hydrogen peroxide (H_2O_2), nitric acid, potassium periodate, hypochlorous acid, [ozoe] ozone water, and the like. In the case when the substrate is a silicon substrate having devices for integrated circuits, any contamination due to alkali metals, alkaline earth metals or halides is not desirable, and hence oxidizing agents containing no nonvolatile component are preferred. Ozone water may greatly cause a compositional change with time. Accordingly, among the oxidizing agents listed above, hydrogen peroxide is most preferred. However, oxidizing agents containing a nonvolatile component may be used when the substrate is a glass substrate having no semiconductor devices.